PROJECT FACT SHEET

CONTRACT TITLE: Prediction of Gas Injection Performance for Heterogeneous Reservoir

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PROJECT SITE **CITY**: Stanford **STATE**: CA **CITY**: **STATE**: **CITY**: **STATE**:	**CONTRACT PERFORMANCE PERIOD**: 9/30/1996 to 5/31/2000 **PROGRAM**: Supporting Research **RESEARCH AREA**: Extraction Research **PRODUCT LINE**: RLE

FUNDING (1000'S)	DOE	CONTRACTOR	TOTAL
PRIOR FISCAL YRS	1036	217	1253
FY 2001 CURRENT OBLIGATIONS	0	0	0
FUTURE FUNDS	0	0	0
TOTAL EST'D FUNDS	1036	217	1253

OBJECTIVE: To demonstrate how gas injection can be applied to heterogeneous reservoirs.

PROJECT DESCRIPTION:

Background: Of the available suite of advanced oil recovery methods, gas injection presently has the greatest potential for additional oil recovery from US light oil reservoirs. Gas injection, particularly misicble or near-miscible flooding, have hitherto been applied to relatively homogeneous reservoirs. The low viscosity of the injected gas ensures that it will flow rapidly through high permeability zones and fractures. The aim of this project is to extend the range of reservoirs for which gas injection may be applied successfully. Efficient application of gas injection to heterogeneous reservoirs requires the engineer to take advantage of the physical mechanisms that interact to determine oil recovery. This research is a study of these mechanisms, namely phase behavior, nonuniform flow, and crossflow, which offer opportunities for applications of gas injection to near-miscible recovery processes, gravity drainage and recovery from fractured reservoirs.

Work to be Performed: A comprehensive research program is to develop design techniques for gas injection in a variety of different reservoir types. The key idea is to use high permeability flow paths (which may be layers or fractures) to deliver the injected gas (CO2, methane, nitrogen or reservoir gas) to lower permeability zones. Crossflow, controlled by gravity, viscous and capillary forces, is the mechanism that moves the gas from high to low permeability regions, thus increasing recovery.

PROJECT STATUS:

Current Work:

Scheduled Milestones:

The completion of gravity drainage experiments using the CT scanner that measure three phase relative permeabilities	09/98
Prediction of experimental three phase relative permeability using network modeling	09/98
Incorporation of multiphase flow with gravity and compositional effects in a three dimensional streamline model	09/99

Accomplishments: (1) Development of fast, accurate simulation methods. Under this grant a new methodology for reservoir simulation has been developed based on strealines. the new method has been implemented in a three-dimensional simulator that can be applied to follows in heterogeneous resrvoirs of tracres, miscible fluids or waterfloods. Limited application to compositional simulations has also been demonstrated. For physically complex displacements in heterogeneous oil reservoirs, the method is substantially more accurate (less subject to numerical dispersion0 and substantially faster (100 to 1000 times) than conventional finite difference simulation. Development of this simulation technique has continued in the area of nested gridding methods, which can be used to perform large-scale 3D computatios significantly faster than previously available streamline methods. which were already very fast. As a resultof this work, a start-up company, StreaSim technologies, has been formed to commercialize the technology, and the ideas developed as part of this project have been used as part of in-house reserch efforts by BP Amoco and Elf Aquitaine and have been applied to study gas injection projects in field operated by Mobil, ARCO, and BP Amoco.

(2) The formulation of a methodology for the calculation of minimum miscibility pressure (MMP) for gas injection and one-domensional (1D) gas-oil displacements. A thermodunamically rigorous method for MMP calculation has been developped and tested. Inall cases tested so far the new method gives MMPs which are consistent with experimental observations and with detailed compositional simulations (as long as careful attention is paid to correcting for effects of numerical dispersion).recently the ideas behind the new method have been extended to develop an automatic procedure for generating analytical solutions for 1D gas-oil displacements. the new methods are orders of magnitude faster than conventional compositional simulation. Future work will apply the new method to compositional streamline simulation.

(3) Pore level model to compute three phase relative permeability. Three-phase flow (oil,water, and gas0 occors routinely in gas injection projects.better understanding of the physics of three-phase flow is required if accurate predictions of oil recoveryb are to be made for such processes. This wirk work lays the foundation for improved characterization of three-phase flow function needed to predict oil recovery for gas injection, solution gas drive and gas cap expansion processes. Amouel of three-phase flow that incorporates physics at the pore scale has been developed and used to calculate three-phase relative permeability. Norsk Hydro, Statoil, and Arco have used this model to predict oil recovery during gas injection. The method developed is also applicable to migration and cleanup of spilled hydrocarbones and solvents in soils.

(4) Three-phase flow experiments. a benchmark series of three-phase flow experiments has been computed. A CT scanner was used to meaure relative permeability directly. The work was used to test theories of three-phase relative permeability, to guide develoment of gravity drainage strategies for resrvoirs, and to constrain development of improved empirical models for three-phase relative permeabilities.

The project is completed The final report is published.